

Literature Review on Mercury Studies in U.S. National Parks, September 2006

Record	Park/Unit	States	Project Title	Description	Findings	Project Years	Citation or PMIS Project No.
1	Acadia National Park	ME	The effect of fire on mercury cycling in the soils of forested watersheds: Acadia National Park, Maine, USA.	This study compares mercury (Hg) and methylmercury (MeHg) distribution in the soils of two forested stream watersheds at Acadia National Park, Maine, U.S.A. Cadillac Brook watershed, which burned in 1947, has thin soils and predominantly deciduous vegetation. It was compared to the unburned Hadlock Brook watershed, with thicker soil and predominantly coniferous vegetation. Mobilization potential of Hg in the O horizons of the two watersheds was studied with batch adsorption experiments.	Findings indicate that the amount of MeHg is not a function of the total pool of Hg in the watershed, suggesting that landscape factors such as soil pH, vegetation type, or land use history (e.g., fire) may be the determining factors for susceptibility to high Hg in biota. Total Hg content was significantly higher in Hadlock's unburned soils (0.18 kg Hg ha ⁻¹) compared to Cadillac's burned soils (0.13 kg Hg ha ⁻¹). The results of Hg adsorption experiments indicated that the dissolved Hg concentration was controlled by the dissolved organic carbon (DOC) concentration. Methylmercury concentrations, however, were consistently higher in the burned Cadillac O horizon (0.20±0.13 ng Hg g ⁻¹ dry weight) than in the unburned Hadlock O horizon (0.07±0.07 ng Hg g ⁻¹ dry weight). Similarly, Cadillac soils possessed a higher MeHg content (0.30 g MeHg ha ⁻¹) than Hadlock soils (0.16 g MeHg ha ⁻¹). Higher MeHg concentrations in Cadillac soils might reflect faster rates of microbial metabolism due to more rapid nutrient cycling and higher soil pH in the deciduous forest.	1999	Amirbahman, A., P.L. Ruck, I.J. Fernandez, T.A. Haines, and J.S. Kahl. (2004) The effect of fire on mercury cycling in the soils of forested watersheds: Acadia National Park, Maine, USA. Water, Air, and Soil Pollution 152: 313-331.
2	Acadia National Park	ME	Mercury Bioaccumulation in Green Frog (<i>Rana clamitans</i>) and Bullfrog (<i>Rana catesbeiana</i>) Tadpoles from Acadia National Park, Maine, USA	Mercury (Hg) contamination in the northeastern United States, including Acadia National Park (ANP), is well documented and continues to be a public-health issue of great concern. Hg contamination of wild amphibians has received little attention despite mounting evidence and reports of worldwide population declines. This report defines total Hg and methyl Hg concentrations for water, sediment, and green frog and bullfrog tadpoles (~ 1 year of age) from ANP.	Average total Hg concentrations in green frog and bullfrog tadpoles were 25.1±1.5 and 19.1±0.8 Hg ng/g wet wt, respectively. Methyl Hg comprised 7.6-40% of the total Hg in tadpole tissue, and average total Hg levels in tadpoles were significantly different among pond sites. Total Hg in pond water was a significant predictor of tadpole total Hg levels. Dissolved organic carbon was a significant predictor of both total Hg and Methyl Hg in water, and total Hg in water was also strongly correlated with Methyl Hg in water. The methylation efficiency (ME) rates defined as total Hg:Methyl Hg ratio in pond waters sampled at ANP were higher than the reported ME for national parks located in the western region of the United States. Of the ponds sampled at ANP, 44% had ME greater than 10% suggesting that wetland food webs in the park are likely susceptible to high levels of total Hg bioaccumulation.	2003	Bank, MS, C Loftin, A Amirbahman. (2003) USGS Water Research Institute, Annual Technical Report, FY 2003
3	Acadia National Park	ME	Population decline of northern dusky salamanders at Acadia National Park, Maine, USA.	Current and historic distribution of northern dusky salamanders (<i>Desmognathus fuscus fuscus</i>) were reviewed in Acadia National Park (ANP), and intensive surveys for stream salamanders were conducted. Spatial distribution of the average total Hg (ng/g wet wt.) concentrations in Acadia watersheds was measured.	The long-term review reports that the northern dusky salamander at ANP has experienced a significant population decline, with Hg and other atmospheric contaminants as the best likely explanation. Data indicates that streams have high concentrations of total Hg, and suggests that the west side of ANP may have a higher Hg methylation potential and a greater Hg exposure to animal biota. This investigation documents the decline of a stream dwelling amphibian species in a national park with widespread mercury contamination of its surface waters.	1938-2003; 2000-2003	Bank, MS; Crocker, JB; Davis, S; Brotherton, DK; Cook, R; Behler, J; Connery, B. (2006) Population decline of northern dusky salamanders at Acadia National Park, Maine, USA. BIOLOGICAL CONSERVATION, 130 (2): 230-238

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4	Acadia National Park	ME	Litterfall mercury in two forested watersheds at Acadia National Park, Maine, USA	Litterfall can be an important flux of mercury (Hg) to soils in forested landscapes, yet typically the only available data to evaluate Hg deposition is from precipitation Hg monitoring. Litterfall was collected at 39 sampling sites in two small research watersheds at Acadia Nat'l Park, and analyzed for total Hg. Four vegetation classes were designated in this study as hardwoods, softwoods, mixed and scrub.	There were clear differences in the litter Hg concentrations among plant species, which may have important ecological implications for other forms of biota. The mean litter Hg concentration in softwoods (58.8 ± 3.3 ngHg g ⁻¹) was significantly greater than in mixed (41.7 ± 2.8 ngHg g ⁻¹) and scrub (40.6 ± 2.7 ngHg g ⁻¹), and significantly lower than in hardwoods (31.6 ± 2.6 ngHg g ⁻¹). Vegetative canopies significantly increase the total Hg inputs to watersheds compared to bare rock and open area deposition. Natural resource managers concerned with potential exposure of surface waters to Hg should consider vegetated watersheds a greater concern than sparsely vegetated and barren rock watersheds.	2003-2004	Sheehan, KD; Fernandez, IJ; Kahl, JS; Amirbahman, A. (2006) Litterfall mercury in two forested watersheds at Acadia National Park, Maine, USA. WATER AIR AND SOIL POLLUTION, 170 (1-4): 249-265
5	Acadia National Park	ME	Researching Acadia's Waters	Acadia serves as a scientific research site for the national PRIMENet program, monitoring UV radiation, air pollution, and toxic contaminants. The watershed program at Acadia addresses mercury, acid rain, and excess nitrogen issues. To study these issues, researchers have developed a longterm strategy of using small 'gauged' watersheds, measuring the amount and chemistry of water flowing out in the stream, and measuring the amount and chemistry of precipitation inputs. The two watersheds studied, Canon Brook and Hadlock Brook, differ in that much of the upper Canon Brook watershed burned in the 1947 fire and thus have varying vegetation. The goal of researchers is to understand how the vegetative and landscape differences control mercury chemistry and uptake by organisms.	Research revealed that mercury concentrations in fish from some Acadia lakes were among the highest in the nation, leading to a mercury human health advisory for the entire state. However, some lakes have high mercury in their fish, while nearby lakes – seemingly similar – have fish with low concentrations. Early data on mercury support the hypothesis that a fire will vaporize mercury in soils, leading to less mercury in stream water.	1990s	Kahl, S. (2000) Researching Acadia's waters. Friends of Acadia Journal. 5(1):16-17. Spring 2000.
6	Acadia National Park	ME	Mercury in Tree Swallow Food, Eggs, Bodies, and Feathers at Acadia National Park, Maine	Nest boxes were monitored at Acadia National Park, Mt. Desert Island, ME and at an old-field site in Orono, ME to determine mercury (Hg) uptake in tree swallow (Tachycineta bicolor) eggs, tissues, and food boluses. Breeding success was recorded at all locations.	On average, total mercury (THg) biomagnified 2 to 4-fold from food to eggs and 9 to 18-fold from food to feathers. These are minimum values because the proportion of transferable methyl mercury (MeHg) of the THg in insects varies (i.e., 35%–95% of THg) in food boluses. THg was highest in food boluses at Aunt Betty Pond at Acadia. A few eggs from nests at each of these locations exceeded the threshold (i.e., 800–1,000 ng/g, wet wt.) of embryotoxicity established for Hg. Hatching success was 88.9% to 100% among locations. MeHg in feathers was highest in tree swallows at Aunt Betty Pond and the concentration of THg in bodies was related to the concentration in feathers. Transfer of an average of 80%–92% of the Hg in bodies to feathers may have enhanced nestling survival.	1997-1999	Longcore, JR, TA Haines, WA Halteman. Mercury in Tree Swallow Food, Eggs, Bodies, and Feathers at Acadia National Park, Maine, and an EPA Superfund Site, Ayer, Massachusetts. Envir. Mon. Assess.

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7	Acadia National Park	ME	Comparison of Hg and Pb fluxes to hummocks and hollows of ombrotrophic big heath bog and to nearby Sargent Mt. Pond, Maine, USA	Two hummock cores (separated by 1 m), two hollow cores (separated by 1 m and both within 5 m of the hummock) from ombrotrophic Big Heath, and a single core from Sargent Mountain Pond (12 km north-northeast of the bog), Mt. Desert Island, Acadia National Park Maine, USA were collected and dated using Pb-210 and analyzed for a suite of major and trace metals.	The hummock cores correspond closely in terms of dating profiles, concentrations of Hg and Pb, and thus trends and values for accumulation rates. The hollow cores agree generally with each other but give more subdued peaks in concentration and lower integrated anthropogenic burdens of Hg and Pb and 50% lower unsupported Pb-210 than the hummock cores. Hummock cores agree closely with the lake sediment core with respect to timing of maximum accumulation rates which occurred in the 1970s; Background atmospheric deposition rates of Hg and Pb to coastal Maine appear to have been about 2.5 to 3 ng/cm(2)/yr and <0.2 mu g/cm(2)/yr, respectively. Atmospheric deposition of Hg acid Pb increased to as much as 20 ng/cm(2)/yr and 2 mu g/cm(2)/yr, respectively, by the 1970s and has decreased since then. Probably more than 50% of the Hg and Pb are deposited in dry and occult deposition.	1983	Norton, SA; Evans, GC; Kahl, JS. (1997). Comparison of Hg and Pb fluxes to hummocks and hollows of ombrotrophic big heath bog and to nearby Sargent Mt. Pond, Maine, USA WATER AIR AND SOIL POLLUTION, 100 (3-4): 271-286.
8	Acadia National Park, Shenandoah National Park	ME VA	Mercury bioaccumulation in northern two-lined salamanders from streams in the northeastern United States	Concentrations of total Hg in larval northern two-lined salamanders were reported from 3 locations: (1) Acadia National Park (ANP), (2) Bear Brook Watershed, Maine (an ammonium sulfate treatment site), and (3) Shenandoah National Park, Virginia. Adult two-lined salamanders and juvenile 1–2 year old brook trout were simultaneously collected from ANP to evaluate differences in Hg bioavailability among species and salamander age classes.	The majority of Hg in salamanders at ANP was in the MeHg (73–97%) form. At ANP total Hg concentrations in salamander larvae were significantly higher from streams in unburned watersheds than those from streams located in watersheds burned by fire. Total Hg levels were significantly higher in salamander larvae collected at ANP in contrast with SNP. Data from the ammonium treatment site indicate that Hg bioaccumulation was higher in salamander larvae collected from this stream, presumably as a result of increased MeHg production by enhanced anaerobic, sediment based, sulfate reducing bacteria activity and efficient transfer through the food web. Results suggest that watershed-scale attributes including fire history, whole-catchment (NH ₄) ₂ SO ₄ additions, wetland extent, and forest cover type influence mercury bioaccumulation in salamanders inhabiting lotic environments. Additionally, larvae and adult two-lined salamanders had significantly higher total Hg concentrations than juvenile (1–2 years of age) brook trout collected from the same stream in ANP.	2000-2002	Bank, MS; Loftin, CS; Jung, RE. (2005) Mercury bioaccumulation in northern two-lined salamanders from streams in the northeastern United States. ECOTOXICOLOGY, 14 (1-2): 181-191
9	Big Bend National Park	TX	Environmental contaminants in prey and tissues of the peregrine falcon in the Big Bend Region, Texas, USA.	Peregrine falcons have been recorded nesting in Big Bend National Park since the early 1900s, but productivity rates had been very low and suspected to be caused by environmental contaminants. To evaluate potential impacts of contaminants on peregrine falcon populations, likely avian and bat prey species were collected primarily in BIBE. Mercury was measured in feathers and liver of the three peregrine falcon carcasses collected in Big Bend National Park.	Mercury levels in birds and bats collected in 1994 were low; however, those collected in 1997 were above levels in the diet that have been associated with negative effects in some birds (i.e., methyl mercury levels of 0.5 mg/g dw in the diet of mallards reduced egg laying and hatching success; common loons experienced reduced clutch size, increased nest desertion, and decline of nesting territories when they fed on prey containing 1–1.2 mg/g dw organic mercury). All five insectivorous species collected in 1997 had Hg levels above 0.4 mg/g dw, a value accepted as threshold for protection of fish-eating birds.	1994 1997	Mora, M; Skiles, R; McKinney, B; Paredes, M; Buckler, D; Papoulias, D; Klein, D. (2002) Environmental contaminants in prey and tissues of the peregrine falcon in the Big Bend Region, Texas, USA. ENVIRONMENTAL POLLUTION, 116 (1): 169-176

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10	Big Thicket National Preserve	TX	Heavy Metal Analysis in water samples, sediments, and biological tissues	The collection of heavy metals samples in different environmental compartments of BITH goes back to the early 1970s, resulting in thousands of data points.	<p>Hg detected in 29% of the analyzed samples from the early 1970's to the late 1990's. Total [Hg] averaged 1.98 µg/L in non-filtered and 0.38 µg/L in filtered – however – these values are very high and they exceed the safe guidelines for aquatic life in most cases. Prior to 1985 data prone to contamination and considered inaccurate. Actual numbers from late 1980's and thereafter.</p> <p>Sediments less prone to contamination by Hg, thus data is more accurate. Measured [Hg] ranged from 0.006 to 10 mg/kg. A large number of analyzed samples exceed the 0.2 mg/Kg guideline criteria for sediment quality.</p> <p>Six data points for [Hg] in biological tissues, and two samples exhibited [Hg] above the advised safe consumption limit of 0.5 mg/kg.</p>	late 1960's to late 1990's	<p>Hall, RW and KA Bruce. (1996) Characterization of Water Quality in the Water Corridor Units of Big Thicket National Preserve. Department of Ecology and Evolutionary Biology, Rice University.; Hughes, JC, MD Flora, and JC Woods. (1987) Big Thicket National Preserve: Water Quality Report 1984-1986. NPS/Water Resources Division.; Ulery, RL. (1995) NAWQA Program-Pesticides in the Trinity River Basin Study Unit, Texas, 1968-91. USGS Fact Sheet, FS-088-95.</p> <p>In Gulf Coast Review</p>
11	Cape Cod National Seashore	MA	Evaluate Mercury Deposition	Mercury is of special concern at CACO due to the proximity of many upwind sources and waste incineration plant. Using MDN long-term measurements and chemical and meteorological monitoring, understand the toxicity, bioaccumulation, chemistry, and transport of mercury through a regional approach, and peak seasons for mercury contamination. The objective of the second facet of the proposal is to evaluate the potential for adverse effects to aquatic feeding birds from exposure to elevated mercury concentrations within the Seashore.	Work-in-progress	2002 to present	PMIS 66563
12	Cape Cod National Seashore	MA	Evaluate mercury contamination in aquatic environments of Acadia National Park and Cape Cod National Seashore	Analyze fish that represent lower trophic levels or forage fish which would be heavily utilized by aquatic feeding birds.	The environmental presence of mercury at Cape Cod National Seashore is surprisingly elevated and fish tissue concentrations have been found to exceed human health consumption advisory levels.	late 1990's, early 2000's	Haines, TA. (2001) Evaluate mercury contamination in aquatic environments of Acadia National Park and Cape Cod National Seashore. Final Report. 41 pp.

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13	Congaree Swamp National Park	SC	Influence Of Sediment Microbial Community Structure On Mercury Methylation At COSW	This project develops an understanding of the microbial controls that link atmospheric-derived mercury deposited in Congaree National Park to the formation of toxic methylmercury. COSW's acidic, humic-enriched, wetland-influenced waters are characteristic of a mercury-sensitive ecosystem. Microbially mediated processes that influence the efficiency of mercury methylation in the Park sediments were determined by innovative techniques including: ultra-clean sampling for extremely low levels of methylmercury in water and sediment; application of a cost-efficient hydrogen-gas technique to determine terminal electron-accepting processes in the sediment; and characterization of the sediment microbial community structure using real-time Polymerase Chain Reaction methods and laboratory microcosm studies.	Initial findings indicate that the seasonal flooding of the Congaree National Park with iron-rich Congaree River water may be a primary control on the structure of the indigenous microbial community and its associated mercury transformation activities. In response to this finding, an ancillary proposal has been submitted to directly assess the effect of iron-loading on microbial methylation and demethylation rates.	2004-2005	PMIS 94693
14	Everglades National Park	FL	Mercury and major ions in rainfall, throughfall, and foliage from the Florida Everglades.	Monthly integrated bulk and wet deposition samples for Hg and major ions were collected on top of a 16-m sampling tower located in Everglades National Park, one of nine monitoring sites currently in operation as part of the Florida Atmospheric Mercury Study (FAMS). The deposition of Hg to the Everglades was investigated using monthly integrated bulk and wet-only tower based precipitation samples, tower based aerosol Hg samples, and ground based throughfall samples. A small set of foliage samples was collected and analyzed for 'reactive' and total Hg.	There are large differences in the major ion chemistry of the wet and throughfall samples. Annual fluxes of Hg are as follows: bulk, 22-23 $\mu\text{g}/\text{m}^2/\text{yr}$; wet, 23-24 $\mu\text{g}/\text{m}^2/\text{yr}$; throughfall 26-26 $\mu\text{g}/\text{m}^2/\text{yr}$. The concentrations and fluxes of total Hg in bulk deposition, wet deposition, and throughfall are not significantly different. These data demonstrate that the dry deposited Hg is not 'washed off' of, or leached from foliage by rainfall. Results from the chemical reactivity experiments suggest that the leaves accumulate Hg as they mature. The calculated litterfall Hg fluxes are similar to the measured rates of rainfall Hg deposition.	mid-1990's	Guentzel, J.L., W.M. Landing, G.A. Gill, C.D. Pollman. (1998) Mercury and major ions in rainfall, throughfall, and foliage from the Florida Everglades. The Science of the Total Environment 213:43-51.
15	Everglades National Park	FL	Direct Atmospheric Inputs versus Runoff Fluxes of Mercury to the Lower Everglades and Florida Bay	Knowledge of the proportions of atmospheric and runoff inputs of Hg to a depositional environment provides a valuable scientific and management tool. Sediment cores, about were collected from the lower Everglades and Florida Bay at water depths of 0.5-4 m. Sediment accumulation rates and sediment ages were determined with lead isotopes and others.	Direct atmospheric fluxes of excess Hg to sediments in the lower Everglades and Florida Bay currently average $24 \pm 9 \mu\text{g m}^{-2} \text{yr}^{-1}$ and are comparable with recent results from bulk atmospheric deposition. In contrast, present-day runoff fluxes of excess Hg to area sediments are variable, ranging from about 4-160 $\text{g m}^{-2} \text{yr}^{-1}$. The runoff flux now carries 60-80% of the total flux of excess Hg to the sediments in areas near river sloughs but less than 20% of the total flux of excess Hg in more remote areas of Florida Bay. These results show the greater importance of runoff relative to direct atmospheric deposition for Hg inputs to many areas of the lower Everglades and immediately adjacent Florida Bay.	1994-1998	Kang, W.J, JH Trefry, TA Nelsen, and HH Wanless. (2000) Direct Atmospheric Inputs versus Runoff Fluxes of Mercury to the Lower Everglades and Florida Bay. Environ. Sci. Technol. 34: 4058-4063.

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16	Everglades National Park	FL	Variation of total mercury concentrations in pig frogs (<i>Rana grylio</i>) across the Florida Everglades, USA	The Pig Frog (<i>Rana grylio</i>) is an aquatic frog that is an abundant component of the Everglades ecosystem, and is recreationally and commercially hunted in marshes throughout Water Conservation Areas and Big Cypress National Preserve in South Florida. Most of these areas are under fish consumption advisories because of high levels of methylmercury present in game fish tissues. Because it is important to understand how mercury is distributed throughout Pig Frog populations because their consumption from certain areas may present a risk to human health, 88 pig frogs were collected along a north-south transect through the Florida Everglades and leg tissue was sampled.	Total mercury in frog leg tissue was highest from areas protected from harvest in Everglades National Park, with a maximum concentration of 2051 ng/g wet mass. The THg levels in <i>R. grylio</i> leg tissue from most harvested areas are below Federal advisory limits. However, many pig frogs collected permitted harvest sites had THg levels above the USEPA 0.3 mg/kg Fish Tissue Residue Criterion. Spatial patterns in the mercury found among pig frogs were similar to those of other wildlife species from the Everglades. Frogs had high THg levels in areas where alligators and mosquito fish also have high THg. Our data suggests that pig frogs should not be harvested or consumed from sites that exceed federal limits.	2000-2001	Ugarte, CA; Rice, KG; Donnelly, MA. (2005) Variation of total mercury concentrations in pig frogs (<i>Rana grylio</i>) across the Florida Everglades, USA. SCIENCE OF THE TOTAL ENVIRONMENT, 345 (1-3): 51-59
17	Everglades National Park	FL	A probabilistic risk assessment of the effects of methylmercury on great egrets and bald eagles foraging at a constructed wetland in South Florida relative to the Everglades.	This case study summarizes an assessment of risk of methylmercury (MeHg) exposure to fish-eating birds, great egret (<i>Ardea albus</i>) and the bald eagle (<i>Haliaeetus leucocephalus</i>). Exposure models were based on literature-derived life history parameters combined with site-specific MeHg concentrations in water, sediment, and fish. To assess risk, daily MeHg intake by females and cumulative MeHg consumed by nestlings were compared to literature derived effects thresholds. MeHg poisoning in birds can manifest as damage to nervous, excretory, immune, or reproductive systems; avian embryos and hatchlings are particularly vulnerable to its toxic effects.	Simulations indicated MeHg exposures were greatest at a site in the northern Everglades National Park. Simulated exposures at this site reached a level at which some adverse effects may be expected. Results from previous biomonitoring at this site have long indicated the presence of a MeHg "hot spot" in this area.	2001-2003	Rumbold, DG. (2005) A probabilistic risk assessment of the effects of methylmercury on great egrets and bald eagles foraging at a constructed wetland in South Florida relative to the Everglades. HUMAN AND ECOLOGICAL RISK ASSESSMENT, 11 (2): 365-388
18	Everglades National Park	FL	Levels of mercury in alligators (Alligator mississippiensis) collected along a transect through the Florida Everglades	As part of a multi-agency study of alligator health, 28 American alligators (<i>Alligator mississippiensis</i>) were captured along a transect through the Florida Everglades. Liver and tail muscle tissues were sampled and analyzed on a wet weight basis for total mercury (THg) using cold-vapor atomic absorption spectrophotometry.	All tissues had detectable concentrations of THg that ranged from 0.6 to 17 mg/kg in liver and from 0.1 to 1.8 mg/kg in tail muscle. THg concentrations in tissue differed significantly among locations, with animals from Everglades National Park (ENP) having mean concentrations of THg in liver (10.4 mg/kg) and tail muscle (1.2 mg/kg) that were twofold higher than basin-wide averages (4.9 and 0.64 mg/kg, respectively). The reasons for higher contamination of ENP alligators were unclear and could not be explained by differences in sex, length, weight or animal age. Spatial patterns in isotopic composition did not explain the elevated THg levels in ENP alligators, thus it appears that ENP alligators were more highly exposed to mercury in their environment than individuals in other areas.	1999	Rumbold, DG; Fink, LE; Laine, KA; Niemczyk, SL; Chandrasekhar, T; Wankel, SD; Kendall, C. (2002) Levels of mercury in alligators (<i>Alligator mississippiensis</i>) collected along a transect through the Florida Everglades. SCIENCE OF THE TOTAL ENVIRONMENT, 297 (1-3): 239-252

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19	Everglades National Park	FL	Mercury in Livers of Wading Birds in Southern Florida.	Mercury was measured in livers from 144 wading birds representing seven species collected from four different areas in southern Florida, including the Everglades National Park.	Birds collected from an area encompassing the central Everglades and eastern Florida Bay had significantly greater concentrations of hepatic mercury than did birds from other collection areas. Livers from fledgling and young adult birds contained approximately three times the concentration of mercury as livers from nestling birds. Bird species whose prey base consists of larger fish were found to have approximately four times the hepatic concentration of mercury as did those species which consume smaller fish or crustaceans. Birds with minimal to moderate amounts of body fat had two to three times the concentration of hepatic mercury as birds with relatively abundant body fat reserves. Four great blue herons collected from the central Everglades contained liver mercury at concentrations typically associated with overt neurologic signs (greater than or equal to 30 $\mu\text{g/g}$), and between 30% and 80% of potential breeding-age birds collected contained hepatic mercury at concentrations associated with reproductive impairment in ducks and pheasants.	1990's	SUNDLOF, SF; SPALDING, MG; WENTWORTH, JD; STEIBLE, CK. (1994) MERCURY IN LIVERS OF WADING BIRDS (CICONIIFORMES) IN SOUTHERN FLORIDA. ARCHIVES OF ENVIRONMENTAL CONTAMINATION AND TOXICOLOGY, 27 (3): 299-305.
20	Fort McHenry National Monument & Historic Shrine	MD	Metals in waterfowl livers	Various species of waterfowl were collected from Baltimore Harbor and Rhode River to assess metal concentrations in liver.	Concentrations of lead were consistently greater and are considered to be "elevated" in liver of black ducks (<i>Anas rubripes</i>), mallards (<i>Anas platyrhynchos</i>), canvasbacks (<i>Aythya valisineria</i>), and scaup (<i>Aythya</i> spp.) from Baltimore Harbor compared to birds collected from the Rhode River. Concentrations of cadmium, chromium, mercury and selenium in liver were similar among the two study sites.	1987-1989	Tome, M. Unpublished observations of metals in liver tissue of ducks collected from Baltimore Harbor.
21	Fort McHenry National Monument & Historic Shrine	MD	Metals in surface waters	Zinc, mercury, nickel and copper have all been listed as metals impairing surface waters within this area. Three studies have looked at metals.	Only Beyer et al. (1990) finding greater concentrations of lead, zinc, copper, cadmium, arsenic, and selenium in the house mouse.	1987-1989; 1990; 2000-2002	Beyer, W.N. et al. (1990) Trace elements in soil and biota in confined disposal facilities for dredged materials. Environ. Pol. 65:19-32.; Golden, N.H.; B.A. Rattner, et al. (2003) Concentrations of metals in feathers and blood of nestling black-crowned night-herons (<i>Nycticorax nycticorax</i>) in Chesapeake and Delaware Bays. Bull. Environ. Contam. Toxicol. 70:385-393.; Tome, M. Unpublished observations of metals in liver tissue of ducks collected from Baltimore Harbor.

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22	Glacier National Park	MT	Mercury in Remote Rocky Mountain Lakes of Glacier National Park, Montana, in Comparison with other Temperate North American Regions	Concentrations of mercury (Hg) and methylmercury (MeHg) in 12 pristine lakes of Glacier National Park (GNP) were determined and compared our observations with data from published studies of remote lakes in north-central Wisconsin and the Adirondack region of New York.	Despite marked differences in water chemistry, biology, and hydrogeology, concentrations of Hg and MeHg in all regions were strongly correlated with dissolved organic carbon (DOC). Variables related to the acid-base status of lake waters had secondary effects on the concentration of waterborne mercury species. Although Hg and MeHg were strongly correlated with DOC in all three regions, MeHg concentrations were lower and increased less per unit organic carbon in GNP lakes than in either Wisconsin or New York. In GNP lakes, MeHg averaged only 4 +/- 2% of the Hg, while in Wisconsin and New York lakes MeHg averaged 10-14% of the Hg.	1990's	WATRAS, C.J; MORRISON, KA; BLOOM, NS. (1995) MERCURY IN REMOTE ROCKY-MOUNTAIN LAKES OF GLACIER NATIONAL-PARK, MONTANA, IN COMPARISON WITH OTHER TEMPERATE NORTH-AMERICAN REGIONS. CANADIAN JOURNAL OF FISHERIES AND AQUATIC SCIENCES, 52 (6): 1220-1228.
23	Gulf Islands National Seashore	FL MS	Determine Concentrations of Mercury Compounds in Fish, Water, and Sediments	Recent samples of amberjack, cobia, redbfish, and other species tested by the Mississippi Department of Environmental Quality were found to have methylmercury levels significantly higher than the threshold for government consumption advisories. Since park waters are vulnerable to atmospheric deposition and a substantial portion of park visitors are fishers, a sampling program to determine mercury contamination in the water column, bottom sediments, and fish was conducted. This study assesses both the levels and the extent of Hg contamination in different environmental compartments of selected parks and determines the potential of sediments in these parks to produce and accumulate MeHg. These objectives were addressed by a combination of field observational studies and laboratory investigations of Hg methylation and MeHg demethylation.	<i>Results pending</i>	2003-2005	PMIS 85655 Youn, S. and Bonzongo, J-C.J. 2005. Mercury Levels, Speciation, and Fate in Gulf Coast National Park Aquatic Systems.
24	Gulf Islands National Seashore	FL MS	Heavy metal analysis in water samples and sediments	The levels of metals in biological tissues and, to some extent, in sediments have been poorly documented in GUIs. Most of the compiled data are related only to the metal content of surface waters.	Hg (and Pb) show increasing trends in 1990's in park's surface waters. These trends indicate the probable addition of new Pb and Hg in the water bodies of GUIs. In sediments, the concentrations of Pb (0.36 to 2454 mg/kg) are orders of magnitude greater than the concentrations of Hg (0.1 to 1 mg/kg).	1990's	Barksdale, John D. (2000) Preliminary Investigation of Potential Contamination for Six Sites at the Gulf Islands National Seashore. The Environmental Company, Inc.; Bateman, Diane H. and Michael S. Brim. (1995) Environmental contaminants in loggerhead sea turtle eggs from the northern Gulf of Mexico. U.S. Fish and Wildlife Service/Southeast Region/Atlanta, GA PCFO-EC 95-05. In Gulf Coast Review

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25	Indiana Dunes National Lakeshore	IN	Organochlorines, Mercury, and Selenium in Great Blue Heron Eggs from Indiana Dunes National Lakeshore, Indiana	20 great blue heron eggs were collected from a colony at the Indiana Dunes National Lakeshore. The eggs were artificially incubated until pipping and were then analyzed for organochlorines, mercury, and selenium. Livers of embryos were analyzed for hepatic microsomal ethoxyresorufin-O-dealkylase (EROD) activity. Brains were measured for asymmetry.	Mercury (geometric mean = 0.9 mg/g dry weight) concentrations in great blue heron eggs were within background levels. EROD activity in the embryos analyzed from INDU was not elevated. The frequency (11%) of brain asymmetry was low.	1993	Custer, TW; RK Hines; PM Stewart; MJ Melancon; DS Henshel; DW Sparks. (1998) Organochlorines, Mercury, and Selenium in Great Blue Heron Eggs from Indiana Dunes National Lakeshore, Indiana. J. Great Lakes Res. 24(1):3-11.
26	Isle Royale National Park	MI	Mercury Deposition Network (MDN) Trends	Assess data from MDN site MN18, part of National Atmospheric Deposition Program (NADP).	Volume-weighted mean concentration of Hg in precipitation was 9 ng/L during 1995-1996, mean Hg conc. in precip from 1996-2002 was 13 ng/L. Mean weekly deposition rate 163 ng/m ² .	1995-2002	MDN-NADP
							In Upper Great Lakes Review
27	Isle Royale National Park	MI	Historical changes in mercury contamination in Michigan walleyes Fish Contaminant Monitoring Program, Michigan Department of Natural Resources A comparison of fish communities from 32 inland lakes in Isle Royale National Park	The Michigan Department of Natural Resources (MDNR) analyzes lake trout from Lake Superior waters in the park for a wide range of contaminants, including mercury. In addition, they collect lake trout from Siskiwit Lake. These data are used to help establish fish consumption advisories for the state.	[Hg] in lake trout from Lake Superior below threshold, [Hg] from lake trout in ISRO Siskiwit Lake routinely exceed fish consumption guideline (0.5 ppm), currently and historically.	1970's to 1990's	Kelly, TM et al. (1975). Historical changes in mercury contamination in Michigan walleyes (Stizostedion vitreum vitreum). J. Fish. Res. Board Can. 32 (10):1745-1754.; MIDNR (1997). Fish Contaminant Monitoring Program, Michigan Department of Natural Resources. pp.; Kallemeyn, LW (2000). A comparison of fish communities from 32 inland lakes in Isle Royale National Park, 1929 and 1995-97, U.S. Geological Service, Columbia, MO. USGS/BRD Biological Science Report-2000-0004 pp.
							In Upper Great Lakes Review

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28	Isle Royale National Park	MI	A comparison of fish communities from 32 inland lakes in Isle Royale National Park, 1929 and 1995-97	Kallemeyn of the USGS conducted an extensive study of the fish community structure of Isle Royale, including 32 inland lakes from Isle Royale (Kallemeyn, 2000). He compared his data to a similarly rigorous study conducted in 1929 (Koeltz, 1929) in order to assess the long term changes in fish community structure in the park. In addition, Kallemeyn reported mercury concentrations in fishes from the current study.	[Hg] highest in top predators such as lake trout, walleye, northern pike, intermediate in perch (omnivores), and lowest in benthivores, white sucker and whitefish. Five ISRO lakes had mean Hg concentrations in 610 mm (that's big) pike that exceed the 0.5 ppm Michigan fish consumption guideline.	1929; 1995- 1997	Kallemeyn, LW (2000). A comparison of fish communities from 32 inland lakes in Isle Royale National Park, 1929 and 1995-97, U.S. Geological Service, Columbia, MO. USGS/BRD Biological Science Report-2000-0004 pp. In Upper Great Lakes Review
29	Isle Royale National Park	MI	An Investigation of Mercury Levels in the Food Web	The main objective of the aquatic study was to measure mercury (total and MMHg) in the foodweb of a lake with elevated mercury in northern pike (Sargent Lake) and compare it to a similar lake with low levels of mercury in northern pike (Richie Lake). The factors affecting the differences in bioaccumulation between the lakes were identified and evaluated.	Mercury concentrations in biological tissue dependent upon DOC, suspended particulate matter, chlorophyll a, pigment signatures (hence a greater bioavailability of MMHg to zooplankton), and differences in foodweb structure	1998- 1999	Gorski, PR, Cleckner, LB, Hurley, JP, Armstrong, DE, Garrison, PJ, Sierszen, ME and Engstrom, DE (2002). An Investigation of Mercury Levels in the Food Web of Isle Royale National Park, Michigan: Report for the Aquatic Subproject on Sargent and Richie Lakes, Summer 1998-Summer 1999, National Park Service, Houghton, MI. 75 pp. In Upper Great Lakes Review
30	Isle Royale National Park	MI	An Investigation of Mercury Levels in the Food Web	Reconstruct histories of mercury accumulation in lake sediments	Researchers concluded that the source of mercury to Isle Royale is atmospheric, and that there was no increase in mercury to the inland lakes as a result of local mining activities in the 1870-80s	1998- 1999	Gorski, PR, Cleckner, LB, Hurley, JP, Armstrong, DE, Garrison, PJ, Sierszen, ME and Engstrom, DE (2002). An Investigation of Mercury Levels in the Food Web of Isle Royale National Park, Michigan: Report for the Aquatic Subproject on Sargent and Richie Lakes, Summer 1998-Summer 1999, National Park Service, Houghton, MI. 75 pp. In Upper Great Lakes Review

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31	Isle Royale National Park	MI	Mercury Exposure in the Common Loon (<i>Gavia immer</i>)	Blood and feathers from loons were collected from populations from several inland lakes, including Sargent Lake on Isle Royale, and Lake Superior.	Hg exposure – significantly greater in juvenile loons from ISRO than those from Lake Superior. Mean blood conc. 1.06 µg/mL. 10% of adults from ISRO had feather conc. greater than 20 ppm, a benchmark for risk of toxic effects	mid to late 1990's	Kaplan, JD and Tischler, KB (2000). Mercury Exposure in the Common Loon (<i>Gavia immer</i>) at Isle Royale National Park, MI, National Park Service, Houghton, MI. NRBIB #ISRO-2156 22 pp. In Upper Great Lakes Review
32	Isle Royale National Park	MI	Mercury concentrations in deer mouse (<i>Peromyscus maniculatus</i>) tissues from Isle Royale National Park	Evaluate deer mice livers for mercury	Hg concentrations in deer mice livers were greater outside the Sargent Lake watershed in ISRO, supporting the conclusion that the differences in fish Hg conc. in the inland lakes are a result of in-lake processes and not related strongly to the watershed.	mid to late 1990's	Vucetich, LM, Vucetich, JA, Cleckner, LB, Gorski, PR and Peterson, RO (2001). Mercury concentrations in deer mouse (<i>Peromyscus maniculatus</i>) tissues from Isle Royale National Park. Environmental Pollution (Oxford, United Kingdom) 114(1): 113-118. In Upper Great Lakes Review
33	Isle Royale National Park	MI	Mercury deposition in teeth from moose and humans in the vicinity of Isle Royale National Park	Deciduous teeth from moose have been used as bioindicators of mercury exposure and to examine time trends of contamination (Eide et al., 1997). Metals are incorporated into the dentine at the time of tooth formation.	Deciduous teeth from moose indicate that Hg concentrations increased from 1945-1980, and have declined since then. Results consistent with other reports of declining Hg atmospheric concentrations.	1945-2002	Peterson, RO; et al. (2002). Mercury deposition in teeth from moose and humans in the vicinity of Isle Royale National Park (unpublished manuscript); Engstrom, DR and Swain, EB (1997). Recent declines in atmospheric mercury deposition in the upper Midwest. ES&T 31 (4): 960-967; Pirrone, N; I Allegriani; et al (1998). Historical atmospheric mercury emissions and depositions in North America compared to mercury accumulations in sedimentary records. Atmos. Envir. 32: 929-940. In Upper Great Lakes Review

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34	Isle Royale National Park	MI	Methyl and total mercury in precipitation in the Great Lakes region	Methylmercury (MeHg) and total mercury (THg) concentrations were measured in precipitation collected from five US sites in the Great Lakes region: three sites on the southern shore of Lake Superior (Brule River, WI, Eagle Harbor, MI, and Tahquamenon Falls, MI), one at Isle Royale National Park (MI), and one in southern Wisconsin (Devil's Lake).	Average THg concentrations at Isle Royale were equal to 19.0 ng L ⁻¹ , with at least 5% of all events collected with THg concentrations exceeding 40 ng L ⁻¹ , and one event at Isle Royale, 129.6 ng L ⁻¹ . Detectable MeHg concentrations were measured in the majority (84%) of precipitation samples at all sites and ranged from 0.01 to 0.85 ng L ⁻¹ . The frequency of events with MeHg concentrations exceeding 0.30 ng L ⁻¹ at Isle Royale was 13%. Three hypotheses on the source of MeHg in precipitation were proposed: 1. MeHg is formed in association with "lake-effect" clouds and fogs, 2. MeHg is emitted from wetlands near Lake Superior, and 3. DMHg is fluxed from deep regions of Lake Superior and is transformed to MeHg which is removed from the atmosphere in precipitation.	1997-2003	Hall, BD; Manolopoulos, H; Hurley, JP; Schauer, JJ; St Louis, VL; Kenski, D; Graydon, J; Babiarz, CL; Cleckner, LB; Keeler, GJ. (2005). Methyl and total mercury in precipitation in the Great Lakes region. <i>ATMOSPHERIC ENVIRONMENT</i> , 39 (39): 7557-7569
35	Isle Royale National Park	MI	Factors affecting enhanced mercury bioaccumulation in inland lakes of Isle Royale National Park, USA.	Factors causing mercury (Hg) concentrations in northern pike to exceed the consumption advisory level >500 ng/g in some inland lakes of Isle Royale National Park were investigated. Using Hg-clean techniques, water, zooplankton, macro invertebrates, and fishes were collected from one advisory lake, Sargent Lake, for analysis of total mercury (HgT) and methylmercury (MeHg). For comparison, samples were also collected from a non-advisory lake, Lake Richie. Carbon and nitrogen stable isotopes were quantified for food web analysis.	Concentrations of HgT in northern pike were significantly higher in Sargent Lake. Counter to expectations, mean concentrations of both HgT and MeHg in open water samples were slightly higher in Lake Richie. However, zooplankton in Sargent Lake contained higher average concentrations of HgT and MeHg than in Lake Richie. Mercury concentrations in macro invertebrates were similar between lakes, but different between taxa. The two lakes exhibited similar HgT concentrations in age-1 yellow perch and adult perch but concentrations in large adult perch >160 mm in Sargent Lake were twice the concentrations in Lake Richie. Analysis of stable isotopes in biota showed that pike from the two lakes are positioned at the same trophic level, but that the food web is more pelagic-based in Sargent and benthic-based in Richie. Factors causing concentrations in large pike to be higher in Sargent Lake may include higher bioavailability of methylmercury and a food web that enhances bioaccumulation.	1998-1999	Gorski, PR; Cleckner, LB; Hurley, JP; Sierszen, ME; Armstrong, DE. (2003). Factors affecting enhanced mercury bioaccumulation in inland lakes of Isle Royale National Park, USA. <i>SCIENCE OF THE TOTAL ENVIRONMENT</i> , 304 (1-3): 327-348
36	Jean Lafitte National Historic Park and Preserve	LA	Heavy Metal Analysis of water samples, sediments, and biota	Assess persistent organochlorines and heavy metal data	Temporal trends show declining levels of Hg (and Pb) in water samples, with suspicious data prior to the mid-1980s. Therefore, temporal trends that include data prior to the late 1980s are probably not accurate. The sediments and biota data are probably good, and they tend to show a decline over time.	1970's to 1990's	Baron, J and B Newkirk. (1992). Preliminary Analysis of Water Quality of the Barataria Unit of Jean Lafitte National Historic Park. Applied Research Branch, Water Resources Division, NPS. Colorado State University.; Garrison, CR. 1982. Water Quality of the Barataria Unit, Jean Lafitte National Historical Park, Louisiana (April 1981-March 1982) U.S.G.S. Open-File Report 82-691. In Gulf Coast Review

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37	Lake Roosevelt National Recreation Area	WA	Concentrations of mercury and other trace elements in walleye, smallmouth bass, and rainbow trout in Franklin D. Roosevelt Lake and the upper Columbia River, Washington	Sample sport fish from the upper Columbia River and Franklin D. Roosevelt Lake (Lake Roosevelt) for concentrations of mercury and other trace elements	Walleye had higher concentrations of mercury than other sport fish, and larger walleye had higher mercury concentrations than smaller walleye. Mercury concentrations in walleye filets ranged from 0.11 to 0.44 parts per million (ppm).	1994	Munn, M.D., Cox, S.E., and Dean, C.J., (1995). Concentrations of mercury and other trace elements in walleye, smallmouth bass, and rainbow trout in Franklin D. Roosevelt Lake and the upper Columbia River, Washington, 1994: U. S. Geological Survey Open-File Report 95-195, 35 p. (For copies, write or call: Earth Science Information Center, Box 25286, MS517, Denver Federal Center, Denver CO 80225; (303) 202-4210.)
38	Mount Rainier National Park	WA	Mercury Concentrations in Fish from High Elevation Lakes and Sediments in Washington's Class I national parks	In 2002, 14 lakes in 3 State of Washington national parks were sampled, with elevations ranging from 3200-6300 ft. Fish were collected with a light-weight gillnet, weights and lengths recorded, a composite sample of 5 fish, males preferred. Analysis at ppb level for organochlorines and Mercury. In 2003, fish tissues at 5 lakes in MORA and NOCA were re-sampled. Total and methyl mercury were sampled from sediments.	Hg was detected in all tissue samples. The average mercury concentration in fish was 50 ppb. Hg was detected at low end of background soil concentrations; methyl mercury was a very low percentage of total.	2002-2003	Moran, Patrick and Bob Black. (2004). Toxic Air Contaminants in Fish from High Elevation Lakes in Washington's National Parks. USGS WRD Tacoma (unpublished data)
39	Natchez Trace Parkway and National Scenic Trail	MS	Heavy Metal Analysis of water samples, sediments, and biota	Monitor NATR heavy metal concentrations	The range of Hg concentrations varied from 0.1 to 2.3 µg/L (average = 0.34; n=48) in filtered water samples and from 0.1 to 17 µg/L (average = 1.16; n=65) in the nonfiltered fractions. These numbers show an overall decrease over time, but might be inaccurate due to sampling technique. In sediments, Hg concentrations (range: 0.02 – 20, average = 2.20; n=20) decrease from high values recorded in the beginning of the monitoring program. Hg concentrations in biological tissues vary from 0.1 to 2.7 mg/kg, with an average value of 0.36 mg/kg (n=23).	1970's to 1990's	Schmitz, Darrel W. (2001). Fourth Quarter 2001 Ground Water Data 2001, Correspondence, Professor, Miss.; Knight, SS and CM Cooper. (1996). Insecticide and metal contamination of a mixed cover agricultural watershed. Water Science and Technology 33(2): 227-234.
							In Gulf Coast Review

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40	National Capital Parks - East	DC	Are anuran amphibians heavy metal accumulators?	Adult and larval amphibians (<i>Rana catesbeiana</i> , <i>R. clamatus</i> , <i>Rana</i> spp., <i>Bufo</i> spp.) were collected from the Patuxent Wildlife Research Center to determine heavy metal concentrations in tissues.	Mercury concentrations, which ranged from 0.04-0.1 µg/g ww in 136 tadpoles, <0.01-0.14 µg/g in adult frogs, and 0.04-0.14 µg/g in toads, were comparable to other uncontaminated areas.	early 1980's	Hall, R.J. and B.M. Mulhern. (1984). Are anuran amphibians heavy metal accumulators? Pages 123-133 in: R.A. Seigel, L.E. Hunt, J.L. Knight, L. Malaret, and N.L. Zuschlag, editors. Vertebrate Ecology and Systematics. Museum of Natural History, University of Kansas, Lawrence, Kansas.
In Mideastern US Review							
41	National Capital Parks - East	DC	Nationwide residues of mercury, lead, cadmium, arsenic, and selenium in starlings, 1973	European starlings (<i>Sternus vulgaris</i>) were collected from 51 sites nationwide, including Patuxent, MD, as part of the National Pesticide Monitoring Program to determine mercury, lead, cadmium, arsenic, and selenium residues.	Patuxent's starlings contained comparable concentrations of lead, cadmium, arsenic and selenium as other areas in the United States (Mean = 1.10 Pb µg/g ww; 0.08 Cd; 0.06 As; 0.36 Se). Approximately 60% of the starling tissue analyzed throughout the United States contained no detectable concentrations of mercury including starlings from Patuxent, MD.	1973	White, D.H., J.R. Bean, and J.R. Longcore. (1977). Nationwide residues of mercury, lead, cadmium, arsenic, and selenium in starlings, 1973. Pesticides Monitoring Journal 11:35-39.
In Mideastern US Review							
42	North Cascades National Park	WA	Mercury Concentrations in Fish from High Elevation Lakes and Sediments in Washington's Class I national parks	In 2002, 14 lakes in 3 State of Washington national parks were sampled, with elevations ranging from 3200-6300 ft. Fish were collected with a light-weight gillnet, weights and lengths recorded, a composite sample of 5 fish, males preferred. Analysis at ppb level for organochlorines and Mercury. In 2003, fish tissues at 5 lakes in MORA and NOCA were re-sampled. Total and methyl mercury were sampled from sediments.	Hg was detected in all tissue samples. The average mercury concentration in fish was 59 ppb. Hg was detected at low end of background soil concentrations; methyl mercury was a very low percentage of total.	2002-2003	Moran, Patrick and Bob Black. (2004). Toxic Air Contaminants in Fish from High Elevation Lakes in Washington's National Parks. USGS WRD Tacoma (unpublished data)

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43	Olympic National Park	WA	Fish Mercury Concentrations from High Elevation Lakes in Washington's Class I national parks	In 2002, 14 lakes in 3 State of Washington national parks were sampled, with elevations ranging from 3200-6300 ft. Fish were collected with a light-weight gillnet, weights and lengths recorded, a composite sample of 5 fish, males preferred. Analysis at ppb level for organochlorines and Mercury.	Hg was detected in all tissue samples. The average mercury concentration in fish was 46 ppb.	2002-2003	Moran, Patrick and Bob Black. (2004). Toxic Air Contaminants in Fish from High Elevation Lakes in Washington's National Parks. USGS WRD Tacoma (unpublished data)
44	Palo Alto Battlefield National Historic Site	TX	Heavy Metal Analysis of Water Samples, Sediments, and Fish Tissue	Monitor PAAL heavy metal concentrations	<p>Hg data obtained from the analysis of water samples show very high values, but these numbers remain suspicious due to the antiquated sampling methods utilized prior to the mid-1980's. Hg concentrations averaged 0.37 µg/L in non-filtered water samples, and 0.182 µg/L for the dissolved fraction.</p> <p>Sediment data do not support the high levels measured in water samples, in that sediment levels (average 0.066 mg/kg) are characteristic of non-contaminated systems while Hg levels in water compare to those reported for water bodies impacted by the use of Hg-amalgamation technique in gold mining.</p> <p>Suspicion reinforced by the reported Hg levels in fish tissues (average= 0.075 mg/kg), which are below USEPA's goal of 0.3 mg/kg.</p>	1990's	<p>King, KA., TW. Custer, and JS. Quinn. (1991). Effects of mercury, Selenium, and organochlorine contaminants on reproduction of Forster's terns and black skimmers nesting in a contaminated Texas bay. Archives of Environmental Contamination and Toxicology 20: 32-40; Mora, MA., et.al. (2001). A comparative assessment of contaminants in fish from four resacas of the Texas, U.S.A. - Tamaulipas, Mexico border region. Environmental International 27: 15-20</p> <p>In Gulf Coast Review</p>
45	Pictured Rocks National Lakeshore	MN MI WI	Assessing Mercury Levels in River Otters for Upper Great Lakes Parks	Mercury contamination in Upper Great Lakes parks is a continuing concern to natural resource managers. Bioaccumulation of mercury is best represented in higher trophic species. This project will use mercury levels from river otter hair to determine the minimum amount of mercury in hair that equates to adverse effects on river otters. This tool will assess the threat of mercury to top predators of aquatic ecosystems.	Research in progress.	2006	PMIS 74432

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46	Rocky Mountain National Park	CO	Mercury transport in a high-elevation watershed in Rocky Mountain National Park, Colorado.	Mercury (Hg) was measured in stream water and precipitation in the Loch Vale watershed in Rocky Mountain National Park, Colorado, during 2001–2002 to investigate processes controlling Hg transport in high-elevation ecosystems.	Total Hg concentrations in precipitation ranged from 2.6 to 36.2 ng/L and showed a strong seasonal pattern with concentrations that were 3 to 4 times higher during summer months. Annual bulk deposition of Hg was 8.3 to 12.4 µg/m ² , similar to deposition rates in the Midwestern and Northeastern U.S. Total Hg concentrations in streams ranged from 0.8 to 13.5 ng/L and were highest in mid-May on the rising limb of the snowmelt hydrograph. Stream-water Hg was positively correlated with dissolved organic carbon suggesting organically complexed Hg was flushed into streams during the early stages of snowmelt. Methylmercury (MeHg) in stream water peaked at 0.048 ng/L just prior to peak snowmelt but was at or below detection (<0.040 ng/L) for the remainder of the snowmelt season. Concentrations of MeHg in stream water and corresponding watershed fluxes were low, indicating low methylation rates or high demethylation rates or both.	2001–2002	<p>Mast, M.A., D.H. Campbell, D.P. Krabbenhoft, and H.E. Taylor. (2005). Mercury transport in a high-elevation watershed in Rocky Mountain National Park, Colorado. <i>Water, Air, and Soil Pollution</i> 164: 21–42.</p> <p>Mast et al. (2002). Atmospheric Deposition of Nutrients, Pesticides, and Mercury in Rocky Mountain National Park, Colorado, USGS Water-Resources Investigations Report 03–4241.</p>
47	San Antonio Missions National Historical Park	TX	Heavy Metal Analysis of Water Column and Sediments	Intensive long-term monitoring programs have been conducted in SAAN for many heavy metals, but many data points were collected prior to the adoption of ultra-clean sampling techniques.	730 data points were compiled for Hg alone, but only 153 (21%) positive data points were discussed. However, the impact cannot be evaluated. In addition, the fact that most of the Hg values determined on samples collected after 1985 are greater than 100 ng/L could suggest that these sites are highly contaminated with Hg. However, more reasonable values are reported in sediments, ranging from 0.01 to 0.12 mg/kg (or 10 to 120 ppb). With such low values in sediments, it is hard to explain the high levels reported for samples taken from the water column.	1970's to 1990's	<p>Ward, George H. and Neal E. Armstrong. (1997). Current status and historical trends of ambient water, sediment, fish and shellfish tissue quality in the Corpus Christi Bay National Estuary Program study area. Coastal Bend Bay and Estuary Program CCBNEP- 13 231.</p> <p>In Gulf Coast Review</p>
48	Shenandoah National Park	VA	Evaluate Bioaccumulation of Mercury in Fish	The principal goal of the study is to determine the presence and extent of a mercury contamination in brook trout populations within the Distribution, abundance, and variability of mercury in fish within Shenandoah National Park was determined, and the relationship between stream water chemistry and mercury accumulation in brook trout was assessed. The scope of the study includes 15 park streams comprising varying ANC zones, two sites (low and high elevation) at each stream, and collection of 15 brook trout ranging from age zero (young-of-year) to age three at each site for mercury analysis.	Results pending	2004	PMIS 93874

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49	Shenandoah National Park	VA	Compartmentalization of mercury in biotic components of terrestrial flood plain ecosystems adjacent to the South River at Waynesboro, VA	Small mammals, invertebrates, soil, and plants were collected from the South River Flood Plain, Waynesboro, VA above (control) and below a mercury point source.	White-footed mice (<i>Peromyscus leucopus</i>) and short-tailed shrews (<i>Blarina brevicauda</i>) from the downstream sites contained higher concentrations of mercury in tissues (Mean: mouse = 2.17 µg/g; shrew = 27.5 µg/g) than from the control sites. Mercury residues were not detected in meadow voles (<i>Microtus pennsylvanicus</i>) from the downstream sites.	1983-1984	Cocking, D., R. Hayes, M.L. King, M.J. Rohrer, R. Thomas, and D. Ward. (1991). Compartmentalization of mercury in biotic components of terrestrial flood plain ecosystems adjacent to the South River at Waynesboro, VA. <i>Water, Air, and Soil Pollution</i> 57-58:171-180.
In Mideastern US Review							
50	Shenandoah National Park	VA	Organochlorine pesticides, PCBs, dioxins and metals in post-term peregrine falcon (<i>Falco peregrinus</i>) eggs from the Mid-Atlantic states: New Jersey, Pennsylvania, Delaware, Maryland, and Virginia – 1993-1999.	Two addled peregrine falcon eggs were measured for eggshell thinning and one egg was collected from Shenandoah NP to determine organochlorine pesticide, PCB, dioxin and metal concentrations as part of a study including other Mid-Atlantic areas.	Peregrine falcon eggs showed an 8.80 and 9.87% shell thinning from pre-1947 measurements. Egg contents contained low levels of mercury (1.01 µg/g dw) and other metals (Cu = 2.38 µg/g dw; Fe = 1.22; Mg = 426; Mn = 1.96; Zn = 65.4) below the levels associated with reproductive impairment. Organochlorine pesticides were below levels (β-BHC = 0.00391; cis-nonachlor = 0.00575; dieldrin = 0.0641; endrin = 0.0234; oxychlordane = 0.146; trans-nonachlor = 0.047; HCB = 0.005; heptachlor epoxide = 0.0663; mirex = 0.116; DDD = 0.0331; DDE = 2.1 µg/g ww) that have been associated with adverse effects in peregrine falcons. Dioxin-like toxicants were lower than the level reported by EPA to cause developmental impairment and embryo mortality in American kestrels.	1993-1993	U.S. Fish and Wildlife Service, Y. Zhao, and K.E. Clark. (2004). Organochlorine pesticides, PCBs, dioxins and metals in post-term peregrine falcon (<i>Falco peregrinus</i>) eggs from the Mid-Atlantic states: New Jersey, Pennsylvania, Delaware, Maryland, and Virginia – 1993-1999. USFWS, Washington Office Project ID: 985000.1. U.S. Fish and Wildlife Service, Virginia Field Office, Gloucester, VA. 42 Pp.
In Mideastern US Review							
51	St. Croix National Scenic Riverway	WI MN	Identify Sources of Mercury and Methylmercury in the St. Croix National Scenic Riverway	Mercury has been detected in fish and mussel tissue in specimens collected from the St. Croix National Scenic Riverway. A fish consumption advisory is currently in place because of potentially dangerous levels of the metal in fish taken from the St. Croix. These increased concentrations also may be a result of naturally occurring minerals in the basin. This project compliments and expands heavy metal monitoring that was done as part of the USGS National Water-Quality Assessment (NAWQA) program to determine the extent and distribution of heavy metals. Samples were collected at 22 surface-water sites in the St. Croix River Basin to characterize total mercury and methylmercury concentrations when streams were at summer low flow.	Total mercury concentrations and yields did not differ between land use categories. Methylmercury concentrations were greater in tributaries draining watersheds characterized by wetland/forest land use compared to tributaries draining agricultural/forest land use, but methylmercury yields did not differ between land use categories. Methylmercury yields in the Namekagon River and Rush Creek were four to five times greater than the mean field for all tributary streams. Loads of both total mercury and methylmercury approximately doubled in the St. Croix River mainstem between site 17 at Nevers Dam and site 18 at Franconia. Results from monthly samples collected May to October in the Namekagon River showed that total mercury and methylmercury concentrations were greater during July.	2000-2001	PMIS 61174

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52	St. Croix National Scenic Riverway	MN WI	Survey Mercury Levels in Fish in the St. Croix River	This project compliments the NAWQA program objectives, a NPS-funded study of trace elements in sediment, and a study of the relation between tributary basin land use/land cover and methylmercury levels in streams. The study provides a mercury tissue index - the concentration of mercury in several species of fish at a specific size/age common to the tributaries and mainstem of the St. Croix River. The index allows comparisons of mercury bioaccumulation spatially, across the basin, and temporally, from year to year.	Fish tissue mercury results appear to correlate with sediment mercury results at some sites. The Rush Creek Site had high fish tissue concentrations and had high sediment and water mercury concentrations.	2004-2005	PMIS 73209
53	Theodore Roosevelt National Park	ND	16-year trends in elements of lichens at Theodore Roosevelt National Park, North Dakota	An epiphytic lichen and a soil lichen in two very closely related genera were sampled and measured for their elemental content in the context of air quality.	Mercury and cadmium decreased approximately 30% over the time period in both species. Factor analysis revealed that soil elements were higher in the soil lichen, indicating there was some soil contamination in that species. Sulfur and mercury were highly enriched in both species relative to the soil, which suggests that the atmosphere is a contributing source of these elements. Sulfur and Hg are very strong candidates for enrichment by pollutants because the park is downwind of many sources of sulfur oxides and heavy metals. Among other elements, Hg was lower at Theodore Roosevelt compared to the early-1990s study at Voyageurs National Park. It may be possible that soil elements are higher in Theodore Roosevelt, while toxic and nutritional elements are higher in Voyageurs.	1982, 1998	Bennett, JP; Wetmore, CM. (2000). 16-year trends in elements of lichens at Theodore Roosevelt National Park, North Dakota. SCIENCE OF THE TOTAL ENVIRONMENT, 263 (1-3): 231-241
54	Voyageurs National Park	MN	Relationship between mercury accumulation in young-of-the-year yellow perch and water-level fluctuations.	A three-year monitoring effort of 14 northeastern Minnesota lakes was conducted to document relationships between water-level fluctuations and mercury bioaccumulation in young-of-the-year (YOY) yellow perch (<i>Perca flavescens</i>) collected in the fall of each year at fixed locations. Six of those lakes are located within or adjacent to Voyageurs National Park and are influenced by dams on the outlets of Rainy and Namakan lakes. One site on Sand Point Lake coincides with a location that has nine years of previous monitoring suitable for addressing the same issue over a longer time frame.	Mean mercury concentrations in YOY yellow perch at each sampling location varied significantly from year to year. For the 12-year monitoring site on Sand Point Lake, values ranged from 38 ng gww-1 in 1998 to 200 ng gww-1 in 2001. For the 14-lake study, annual mean concentrations ranged by nearly a factor of 2, on average, for each lake over the three years of record. One likely factor responsible for these wide variations is that annual water-level fluctuations are strongly correlated with mercury levels in YOY perch for both data sets.	2001-2003	PMIS 61247 Sorensen, JA; Kallemeyn, LW; Sydor, M. (2005). Relationship between mercury accumulation in young-of-the-year yellow perch and water-level fluctuations. ENVIRONMENTAL SCIENCE & TECHNOLOGY, 39 (23): 9237-9243

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55	Voyageurs National Park	MN	Mercury in Soils, Lakes, and Fish in Voyageurs National Park (Minnesota): Importance of Atmospheric Deposition and Ecosystem Factors	Because concentrations of methylmercury in game fish from many interior lakes in Voyageurs National Park substantially exceed criteria for the protection of human health, the importance of atmospheric and geologic sources of mercury to interior lakes and watersheds within the Park was assessed through sediment cores and ecosystem factors associated with variation in methylmercury contamination of lacustrine food webs were identified. Soil horizon analysis identified the sources of Hg. Additionally, contamination of food webs was assessed by analysis of whole, 1-year-old yellow perch (<i>Perca flavescens</i>), a regionally important prey fish. Models developed with the information-theoretic approach (Akaike Information Criteria) identified factors influencing methylmercury concentrations in lake water and fish.	Analyses of soil, bedrock, and sediment cores indicate that atmospheric deposition was the dominant source of mercury to the Park, and sediment core data shows that most of the mercury accumulated in lake sediments during the 1900s was from anthropogenic sources. Mean concentrations of total mercury in unfiltered lake water ranged from 0.45 ng L ⁻¹ to 3.3 ng L ⁻¹ . Corresponding mean concentrations of methylmercury ranged from <0.04 ng L ⁻¹ to 0.30 ng L ⁻¹ . Mean concentrations of total mercury in 1-year-old yellow perch varied more than 5-fold among lakes, ranging from 182 ng g ⁻¹ dry weight to 942 ng g ⁻¹ . These concentrations of total mercury in fish and of methylmercury in lake water varied substantially among lakes, reflecting the influence of ecosystem processes and variables that affect the microbial production and abundance of methylmercury. Lake water pH, dissolved sulfate, and total organic carbon (an indicator of wetland influence) were determined to be factors influencing methylmercury concentrations in lake water and fish.	2000-2002	PMIS 61284 Wiener, JG; BC Knights; MB Sandheinrich; JD Jeremiason; et al. (2006). Mercury in Soils, Lakes, and Fish in Voyageurs National Park (Minnesota): Importance of Atmospheric Deposition and Ecosystem Factors. Environmental Science and Technology
56	Voyageurs National Park	MN	Assess Impacts of Forest Fires on Levels of Mercury in Lake and Forest Environments	The project involved collecting multimedia samples pre- and post-fire from both a fire-treatment watershed and a non-fire reference watershed. Voyageurs has established several intensive sampling sites within proposed prescribed burn areas that characterize vegetation types and fuel loads to assess burn impact. This study intensifies and extends ongoing multimedia sampling to assess the effects of fire on mercury cycling in terrestrial and aquatic environments, and ultimately through the aquatic food web in Voyageurs.	<i>Results pending</i>	2004-present	PMIS 81408
57	Voyageurs National Park	MN	Trends in Atmospheric Mercury Deposition Across Minnesota: Evidence from Dated Sediment Cores from 50 Minnesota Lakes	A study of Hg deposition and the history of accumulation in lake sediments throughout Minnesota. The reconstructed histories of accumulation were used to determine 1) the impacts of local sources compared to those resulting from long-range transport from regional and global sources of mercury; and 2) to assess anthropogenic influences on the rate at which inorganic mercury is converted to MMHg.	Accumulation rate of Hg in lake sediments at VOYA now 36 mg/m ² /year, up from 9 mg/m ² /year prior to European settlement. While accumulation rates have since declined likely to the declining use of mercuric fungicides by area pulp mills, increase in methylation indicate that the exposure to MMHg increased by factors of ~6 since pre-industrial times.	mid 1990's	Engstrom, DE, Thommes, K, Balogh, SJ, Swain, EB and Post, HA (1999). Trends in Atmospheric Mercury Deposition Across Minnesota: Evidence from Dated Sediment Cores from 50 Minnesota Lakes, St. Paul, MN. Final Report to the Legislative Commission on Minnesota Resources 54 pp. In Upper Great Lakes Review

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58	Voyageurs National Park	MN	Six-year trend (1990-1995) of wet mercury deposition in the Upper Midwest. USA	Total mercury was measured in precipitation twice weekly at six sites in North Dakota, Minnesota, and Michigan. The northeastern Minnesota sites included Ely, International Falls, Marcel, and Duluth.	Total Hg from precip 1990-1995, mean annual wet dep was 7.4 mg/m ² /yr, MMHg accounted for 1.5% of total Hg concentrations, on average.	1990-1995	Glass, GE and Sorensen, JA (1999). Six-year trend (1990-1995) of wet mercury deposition in the Upper Midwest. USA. Environmental Science & Technology 33 (19): 3303-3312.
							In Upper Great Lakes Review
59	Voyageurs National Park	MN	Using feathers to assess risk of mercury and selenium to bald eagle reproduction in the Great Lakes Region	Mercury (Hg) and selenium (Se) concentrations were determined in feathers of nestling and adult bald eagles (Haliaeetus leucocephalus) in the Great Lakes region. Relationships between concentrations and two measures of reproduction, productivity and nesting success, were examined.	Decline of Hg in bald eagle nestlings from 20 mg/g in 85-89 to 8.8 mg/g in 99-00; thought to be due to stabilization of water levels (influencing rate of methylation).	1985-1989	Bowerman, WW, Evans, ED, Giesy, JP and Postupalsky, S (1994). Using feathers to assess risk of mercury and selenium to bald eagle reproduction in the Great Lakes Region. Archives of Environmental Contamination and Toxicology 27 (3): 294-8.; Rowe, AS, (2001), The Development of an Avian Biosentinel Program for Michigan using the Bald Eagle (Haliaeetus leucocephalus), MS Thesis, Clemson University.
							In Upper Great Lakes Review
60	Voyageurs National Park	MN	Mercury levels in fish across Minnesota	Study conducted by the US EPA Midcontinent Ecology Division of the National Health and Ecological Effects Research Laboratory in Duluth, Minnesota, looking at mercury levels in fish from about 10 lakes, including lakes in the park.	The highest concentrations of mercury in the study were found in fish from Voyageurs. Northern pike from Ryan and Tooth Lakes were found to have elevated concentrations compared to fish from the rest of the state, a finding confirmed by analyses of samples collected in 2000-2002 by J.G. Wiener, M.B. Sandheinrich (both at University of Wisconsin-La Crosse), B.C. Knights (U.S. Geological Survey), and J. Jeremiason (MPCA).	early 1980's	Glass, USEPA, unpublished
							In Upper Great Lakes Review

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61	Voyageurs National Park	MN	Mercury levels in fish across Minnesota	Sample fish for mercury to assess current concentrations, spatial patterns, and time trends.	These data indicated that fish in the northeastern part of the state had the highest concentrations, including those from lakes in Voyageurs.	1998-1999	Minnesota Fish Contaminant Monitoring Program In Upper Great Lakes Review
62	Voyageurs National Park	MN	Methylmercury Contamination of Fish in Interior Lakes of the Voyageurs National Park: Assessment of Controlling Factors and Effects	The focus of the study is to evaluate the ecosystem characteristics that influence MMHg accumulation in fish. Initially, 1-year-old yellow perch were collected from 15 lakes in the park. These one-year old fish feed primarily on zooplankton and small benthic invertebrates, and thus differences in MMHg should reflect differences in ecosystem production of MMHg rather than foodweb differences.	While concentrations in fish tissue from Tooth Lake were typical for the state (approx. 100 ng/g wet weight), the concentrations in Ryan Lake were about twice that value. Concentrations correlated positively with DOC, an indicator for wetland influence. The researchers have tentatively concluded that extent of connected wetlands will strongly influence MMHg production and bioaccumulation in fish.	2000-present	Wiener, JG, Sandheinrich, MB, Knights, BC, Jeremiason, JD and Rolfhus, KR (2002). Methylmercury Contamination of Fish in Interior Lakes of the Voyageurs National Park: Assessment of Controlling Factors and Effects, University of Wisconsin, La Crosse, WI. Annual Progress Report submitted to the MPCA pp. In Upper Great Lakes Review
63	Voyageurs National Park	MN	Methylmercury Contamination of Fish in Interior Lakes of the Voyageurs National Park: Assessment of Controlling Factors and Effects	Northern pike were also sampled from 11 lakes in the park. A secondary objective of this study is to determine the trophic positions of perch and pike in 11 lakes using stable isotopes of nitrogen	Concentrations of MMHg from northern pike in 2 VOYA lakes found to be 5x greater than for the rest of the state	2000-present	Wiener, JG, Sandheinrich, MB, Knights, BC, Jeremiason, JD and Rolfhus, KR (2002). Methylmercury Contamination of Fish in Interior Lakes of the Voyageurs National Park: Assessment of Controlling Factors and Effects, University of Wisconsin, La Crosse, WI. Annual Progress Report submitted to the MPCA pp. In Upper Great Lakes Review

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64	Voyageurs National Park	MN	Bedrock and Soil Geochemistry from Voyageurs National Park, Minnesota	While the likely explanation for the variation in MMHg concentrations in fish is due to differences in methylation efficiencies related to watershed characteristics, other possible explanations have been explored. To rule out differences in atmospheric deposition, air samples were taken near one of the Voyageurs lakes. Concentrations were not elevated over typical atmospheric background levels. To assess whether natural geological contributions are a source of mercury to these lakes, researchers from the USGS analyzed soil layers and bedrock for mercury.	Elevated MMHg in fish was not a result of increased mercury loading to the lakes from geological sources	1990's	Post, JR, et al. (1996). Uptake rates of food-chain and waterborne mercury by fish: Field measurements, a mechanistic model, and an assessment of uncertainties. Canadian Journal of Fisheries and Aquatic Sciences 53 (2): 395-407.; Woodruff, LG, WF Cannon, et al. (2002). Bedrock and Soil Geochemistry from Voyageurs National Park, Minnesota, US Geological Survey, Mounds View, MN. Open File Report 01-196, (http://pubs.usgs.gov/of/2002/of-196) 8 pp. In Upper Great Lakes Review
65	Voyageurs National Park	MN	Geographic trend in mercury measured in common loon feathers and blood	Mercury exposure to the common loon was measured by sampling both blood and feathers from upper Great Lakes (incl. VOYA/ISRO), Alaska, Pacific NW, New England, Maritimes	Male common loons had significantly greater [Hg] in both feathers and blood than did females. Adults had significantly greater concentrations than juveniles. Increasing gradient of Hg in loons from west to east across N. America, with Great Lakes sites lying in the middle of the concentration range.	1990's	Evers, DC, Kaplan, JD, Meyer, MW, Reaman, PS, Braselton, WE, Major, A, Burgess, N and Scheuhammer, AM (1998). Geographic trend in mercury measured in common loon feathers and blood. Environmental Toxicology and Chemistry 17 (2): 173-183. In Upper Great Lakes Review
66	Voyageurs National Park	MN	Mercury data from small lakes in Voyageurs National Park, northern Minnesota, 2000-02.	Mercury contamination of aquatic ecosystems is a resource concern in Voyageurs National Park. High concentrations of mercury in fish pose a potential risk to organisms that consume large amounts of those fish. The U.S. Geological Survey measured mercury in water collected from 20 lakes in Voyageurs National Park. Those lakes span a gradient in fish-mercury concentrations, and also span gradients in other environmental variables that are thought to influence mercury cycling.	During 2001, near surface methylmercury concentrations ranged from below the method detection limit of 0.04 nanograms per liter (ng/L) to 0.41 ng/L. Near surface total mercury concentrations ranged from 0.34 ng/L to 3.74 ng/L. Hypolimnetic methylmercury ranged from below detection to 2.69 ng/L, and hypolimnetic total mercury concentrations ranged from 0.34 ng/L to 7.16 ng/L. During 2002, near surface methylmercury concentrations ranged from below the method detection limit to 0.46 ng/L, and near surface total mercury ranged from 0.34 ng/L to 4.81 ng/L.	2000-2002	Goldstein, R. M., M. E. Brigham, L. Steuwe and M. A. Menheer. (2003). Mercury data from small lakes in Voyageurs National Park, northern Minnesota, 2000-02. US Department of the Interior, US Geological Survey, Mounds View, MN. Open-File Report 03-480.

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67	Voyageurs National Park	MN	Aquatic Synthesis for Voyageurs National Park	Voyageurs National Park contains significant aquatic resources with about 50% of its total area consisting of aquatic habitat. Mercury contamination significantly impacts VOYA's waters. The purpose of this synthesis is threefold: (1) to provide a complete and integrated account of what is known about the aquatic ecosystem of VOYA; (2) to provide pertinent comparisons from other areas to help park managers better understand the results of research and monitoring efforts within the Park; and (3) to identify needs and potential opportunities for filling gaps in the existing knowledge base. Many questions still need to be answered if the USNPS is to "understand, maintain, restore, and protect the inherent integrity of the natural resources, processes, systems, and values of the Park."	High Hg concentrations in fish in nearly all of the Park's 30 lakes; An inverse relationship between fish Hg concentrations and lake size; Elevated Hg concentrations documented in water, lake sediments, zooplankton and aquatic plants, benthic organisms, piscivorous birds, bald eagles, and river otter; Hg contamination in the Park derived from atmospheric deposition, with three-quarters of this airborne Hg generated by human activities; Although total-Hg has apparently decreased, the methylated portion of Hg increased by a factor of 2-3 between 1940 and 1970; Reservoirs are known to cause a substantial increase in Hg concentrations throughout the food web; Adult birds typically contain significantly higher Hg concentrations than juveniles, particularly in loons; Elevated Hg levels apparent in some of the Park's but it is unknown whether or not the population is being adversely affected; River otter is the only mammal in the Park tested for Hg contamination; Regulating and/or mitigating Hg bioaccumulation point toward aquatic vegetation, a key fulcrum in the seasonal transferral of Hg.	2003	Kallemeyn, L. W., K. L. Holmberg, J. A. Perry and B. Y. Odde. (2003). Aquatic Synthesis for Voyageurs National Park. USGS Biological Resources Division, Springfield, VA. USGS/BRD/ITR - 2003-0001. Mercury and other contaminants pp 70-76.
68	Voyageurs National Park	MN	Chemical element concentrations in four lichens on a transect entering Voyageurs National Park	A three factor transect study was conducted to test the hypothesis that chemical elements from air emissions in the vicinity of International Falls, Minnesota could not be detected in lichens along a 24 km transect reaching into Voyageurs National Park. It was hypothesized that element concentrations in lichens would decline exponentially downwind and would reach background values at a distance before the park boundary. Four species (<i>Cladina rangiferina</i> , <i>Evernia mesomorpha</i> , <i>Hypogymnia physodes</i> , and <i>Parmelia sulcata</i>) were sampled at ten sites for 3 years and 17 chemical elements were measured.	The most notable result was a curvilinear geographic trend for many elements, which decreased from International Falls and then increased towards the park. This trend was significant for many anthropogenic elements, including S, Hg, Cd, and Cr, and for all four species. Tissue concentrations over the 3 years of sampling declined an average of 12%. Sufficient evidence exists to conclude that lichen tissue element concentrations in the vicinity of International Falls may be related to local air emissions, and that an exponential decline of element concentrations downwind of the sources does not apply to this situation.	1990-1992	Bennett, JP and CM Wetmore. (1997). Chemical element concentrations in four lichens on a transect entering Voyageurs National Park. <i>Environmental and Experimental Botany</i> 37:173-185.
69	Yellowstone National Park	WY	Atmospheric mercury speciation in Yellowstone National Park.	Atmospheric concentrations of elemental mercury (Hg ⁰), reactive gaseous Hg (RGM), and particulate Hg (pHg) concentrations were measured in Yellowstone National Park (YNP), U.S.A. using high resolution, real time atmospheric mercury analyzers (Tekran 2537A, 1130, and 1135). Three likely sources of Hg at the intensive monitoring site were investigated: numerous geothermal features scattered throughout YNP, re-suspended soils, and wildfires near or in YNP. Relationships between the chemical properties of aerosols (as measured using real time, single particle mass spectrometry; aerosol time-of-flight mass spectrometer; ATOFMS) and concentrations of atmospheric pHg were examined.	A survey of Hg ⁰ concentrations at various locations within YNP showed that concentrations generally reflect global background concentrations of 1.5–2.0 ng m ⁻³ , but a few specific locations associated with concentrated geothermal activity showed distinctly elevated Hg ⁰ concentrations (about 9.0 ng m ⁻³). At the site of intensive study located centrally in YNP (Canyon Village), Hg ⁰ concentrations did not exceed 2.5 ng m ⁻³ ; concentrations of RGM were generally below detection limits of 0.88 pg m ⁻³ and never exceeded 5 pg m ⁻³ . Concentrations of pHg ranged from below detection limits to close to 30 pg m ⁻³ . RGM and pHg concentrations were not correlated with any criteria gases (SO ₂ , NO _x , O ₃); however pHg was weakly correlated with the concentration of atmospheric particles. Based on the presence of particles with distinct chemical signatures of the wildfires, and the absence of signatures associated with the other sources, it was concluded that wildfires in the park were the main source of aerosols and associated pHg to the sampling site.	2003	Hall, BD; Olson, ML; Rutter, AP; Frontiera, RR; Krabbenhoft, DP; Gross, DS; Yuen, M; Rudolph, TM; Schauer, JJ. (2006). Atmospheric mercury speciation in Yellowstone National Park. <i>SCIENCE OF THE TOTAL ENVIRONMENT</i> 367 (1): 354-366

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70	Yellowstone National Park	MT WY	Organic compounds and trace elements in fish tissue and bed sediment from streams in the Yellowstone River Basin, Montana and Wyoming	Samples were collected at five sites for analysis of mercury in fish muscle and bed sediment, all just outside of Yellowstone National Park	Concentrations of mercury in muscle tissue from predatory game fish ranged from 0.743 to 3.45 µg/g dry weight. Only a small fraction of the mercury present in the bed sediment was in the form of methyl mercury. The percentage of total mercury in the methyl form in the sediment samples ranged from 1.8 % to 11 %. The concentration of methyl mercury in the sediment ranged from 3.05 nanograms per gram (ng/g) dry weight to 0.53 - 0.60 ng/g.	late 1990's	Peterson, D. A. and G. K. Boughton. (2000). Organic compounds and trace elements in fish tissue and bed sediment from streams in the Yellowstone River Basin, Montana and Wyoming, 1998. USGS, Cheyenne WY.
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